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Historical Overview of Fisheries Studies and Sport Fisheries Monitoring Plan for Great Smoky Mountains National Park

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HISTORICAL OVERVIEW OF FISHERIES STUDIES AND SPORT FISHERIES MONITORING PLAN FOR GREAT SMOKY MOUNTAINS NATIONAL PARK

by Mark Alston, Jerry West[1], Mark MacKenzie and Norbert McKinney

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ABSTRACT

Since its establishment in 1934, the Great Smoky Mountains National Park has provided the visitor with the opportunity to fish in the park's many streams. Brook trout, rainbow trout, brown trout, smallmouth bass, and redeye bass provide a varied fishing resource. Over the past 50 years, attempts have been made to protect and improve these fishing resources. The first section of this paper reviews the research and management efforts of the past. One notable failure of past work is the lack of a consistent system of monitoring the amount and the effects of sport fishing on park streams. The second part of this paper presents a statistically valid program for monitoring sport fishing in the Great Smoky Mountains National Park. This program consists of an electroshocking schedule to determine fish population size, and a creel census program to determine fishing pressure and harvest. The monitoring plan contains a random creel sampling schedule to reduce sample bias and standardize sampling sites. It also contains procedures to ensure consistent monitoring of the park's fishing resources.

ACKNOWLEDGEMENTS

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PART I

HISTORICAL OVERVIEW OF FISHERIES STUDIES

Jerry West

INTRODUCTION

The following review of the Great Smoky Mountains National Park (GRSM) fisheries data is based on published papers; popular articles; pamphlets; newspaper clippings; student theses; management reports; correspondence, including memoranda, letters, and reports of telephone conversations; monthly, quarterly, and annual reports; maps; photographs; tables; and checklists. Most of this information is available in the GRSM library and is listed in the bibliography of Carmichael (1979). The purpose of the review was to determine what data are available for the park and to attempt to assess its quality and utility. It was not the purpose to detail all the studies on park fishes. The reader is referred to McCrone et al. (1982) for a more comprehensive list of the studies.

The legislation establishing the park was passed on May 22, 1926, and land acquisition began. Most of the land was acquired by 1934. Powers (1929) described the distribution of trout in several park streams, with emphasis on the brook trout (*Salvelinus fontinalis*). By 1931, many streams had been closed to fishing because, prior to establishment of the park, individual anglers were reported to be taking as many as 100 fish per day. In an attempt to reclaim the populations, a stocking program was begun by the Park Service on some of the streams, and some stocked streams remained closed for up to three years to allow recovery.

The Bureau of Fisheries, the predecessor of the U.S. Fish and Wildlife Service, began studying park fishes in the 1930s. Burrows (1935) surveyed several of the park streams. The purpose of this survey was to determine the biological, chemical, and physical conditions of the streams; to determine species, size, and number of fish for which each stream was best adapted; and to locate possible rearing pool sites.

Thus, within a decade following the passing of the legislation that established the park, many of the streams had been surveyed, the status of the game fish populations had been studied, and new fishing regulations were put into effect. Some logging, overfishing, and other factors had impacted many of the fish populations prior to establishment of the park. A hatchery was established on Kephart Prong with rearing stations in Cades Cove and the Chimneys area to produce rainbow and brook trout for stocking park streams. Interest in the fishes of the park has continued until the present day. They have been studied for at least 50 years. The studies have been in two broad areas: (1) sport fisheries

management, and (2) studies on the native fishes. Since the brook trout is both a sport fish and the only salmonid native to the park, there has been a great deal of interest in this species.

SPORT FISHERIES MANAGEMENT

Sport fishes in the park include the brook trout, the rainbow trout (Salmo gairdneri, the brown trout (Salmo trutta), the smallmouth bass (Micropterus dolomieui), and the rock bass (Ambloplites rupestris). In the early 1900s, during the logging era, the rainbow trout was widely introduced throughout the area now occupied by the park. The introductions were done by logging companies and private citizens. The rainbow was well established in all major drainages by 1910, 20 years before the park was established. Today, the rainbow trout is the dominant sport fish and occupies about 80 percent of the park waters. In the 1950s the brown trout entered the park from peripheral waters stocked by the fish and wildlife agencies of North Carolina and Tennessee. It became established in the park and by 1977 occupied over 50 miles of park streams (Kelley et al. 1980). Both the smallmouth bass and rock bass are natives, but they have not been studied in the park.

Work on sport fisheries began soon after the park was established. Table 1 is a summary of fisheries workers from the National Park Service and the U.S. Fish and Wildlife Service that have studied the sport fishes in the park. All the workers from King to Boaze were concerned mainly with the sport fishery and how to best manage it, especially the brook trout. With the establishment of the Uplands Field Research Laboratory in 1975, some of the later workers (Larson, Moore, Alston) have been concerned with more specific fishery research problems. Except for the 1940s and a short period between Lennon and Parker and Richardson, there has been either a fisheries biologist in residence at the park or stationed at another location but with a major responsibility of managing the park fisheries.

The early workers (King, Barrows, Holloway, Smith, Lennon, and Parker) established baseline and historical data that are very valuable in attempts to determine changes in distribution and numbers of fish in the park. They were also instrumental in establishing fishing regulations, and they were concerned about return of the brook trout to its former range. In the 1970s Jones and Kelly brought a sharper focus to this problem (Jones 1975) and attempted,

Table 1. National Park Service (NPS) and U.S. Fish and Wildlife Service (FWS) fisheries workers in Great Smoky Mountains National Park.

Date	Worker	Agency
1934-1940	King	NPS
1935	Burrows	FWS
1945	Holloway	FWS
1947	Smith	NPS
1952-1960	Lennon and Parker	FWS
1965-1969	Richardson	FWS
1970-1975	Jones	FWS
1972-1978	Kelly	FWS
1978-1981	Crittendon	FWS
1977-1980	Smith	FWS
1981-1983	Boaze	FWS
1979-1983	Larson	NPS
1979-1983	Moore	NPS
1983-1984	Broadbent	NPS
1983-1985	Alston	NPS

unsuccessfully, to get the brook trout of the southern Appalachians listed as a threatened or endangered organism. Smith and Boaze began a sampling program of the lower elevation streams in the 1980s. They established permanent sections and used population estimation techniques that enable better comparisons of numbers and sizes of fish between streams and from year to year. This latter survey provides valuable data for the monitoring program described later in this report. It also provided much of the information on which recommendations were made for a change in fishing regulations in 1983.

The activity of the management biologists up to the 1970s was in four main areas: (1) stocking, (2) recommendations on fishing regulations, (3) surveys of the game fish populations, and (4) determination of angler use of the fisheries resources.

STOCKING

Stocking was an integral part of the park's fisheries management program from 1931 to 1974. From 1936 and through the 1940s, rainbow, a strain of brook trout from New England, and a few native brook trout were reared at the hatchery on Kephart Prong and stocked in park waters. Throughout the stocking era, it was park policy to promote recreational fishing by stocking. However, rainbow were not stocked above natural barriers nor in headwater streams inhabited by native brook trout. Smith (1947) recommended the closing of the Kephart Prong hatchery because of water quality problems and the high cost of rearing the fish. The hatchery was closed soon thereafter and the stocking program was curtailed. Stocking continued until 1974 (later on children's streams), with fish being provided mainly by U.S. Fish and Wildlife Service hatcheries at Pisgah Forest, NC, and Walhalla, SC.

FISHING REGULATIONS

Even though there have been changes in the fishing regulations, they have not been extensive. However, little research has been conducted on the effects of the fishing regulations on sport fishes. The regulations have largely been determined by those of the game and fish agencies of North Carolina and Tennessee in an attempt to keep the regulations uniform, by fish surveys, by the park biologists' opinions of regulations necessary for maintaining reproducing sport fish populations, and by public opinion. When the park was established, some

streams were closed to allow their recovery from overfishing and logging. On others, the regulations included a creel limit of 10 fish, a size limit of 7 inches, and the use of artificial lures only. Also, various streams were closed to fishing to serve as nursery areas for the fish populations. During the late 1940s the regulations were changed. Size limits were removed, natural bait was allowed, and the concept of closing streams for nursery areas was abandoned. In the early 1950s, as a result of Lennon's work, the 7-inch size limit was reestablished, the creel limit was reduced to five, and only single-hook artificial lures were allowed. Lennon also introduced the idea of fishing-for-fun where no fish could be creeled. This program was begun in 1954 on Bradley Fork and the West Prong of the Little Pigeon River. The Oconaluftee River and Little River were added shortly thereafter. This idea led to the concept of sport fishing streams, in which no fish could be creeled, with no closed season. As a result of the work of Ron Jones and Allan Kelly in the 1970s, several changes in the regulations were put into effect in 1975. Brook trout could no longer be creeled, the size limit was increased from 7 to 9 inches on most streams and 12 inches on sport fishing streams, and the creel limit was reduced to four fish. In 1983, as a result of research by the U.S. Fish and Wildlife Service and Uplands Field Research Laboratory, the size limit was again decreased to 7 inches, the creel limit increased to five fish, and the season was opened year round.

SURVEYS AND BROOK TROUT STUDIES

King (1937) surveyed many of the park streams. During the 1950s, Lennon (1967) surveyed 116 of the 335 fishable streams. In the 1970s, Kelly et al. (1980) surveyed almost all of the streams. Boaze and Smith, in the 1980s, surveyed many of the lower elevation streams. These surveys provide the most important fisheries data sets available. Even though attempts were made by Lennon and Kelly to get an estimate of population size and standing crop biomass, the latter surveys are essentially qualitative and are checklists of species present and their relative abundance at the time of sampling. This does not allow the determination of population estimates and their confidence intervals, but it does provide a comparison of the relative abundance between streams, and in the same streams at different sampling times. The surveys of Boaze and Smith do provide quantitative data.

Most of these surveys, as well as those of Burrows (1935), Holloway (1945), and Smith (1947), have noted the reduction in the number of brook trout in the park. King (1937) wrote extensively about this problem. Sullivan (1935) indicated that a determination should be made as to whether the brook trout in the park was a different variety or even a distinct species. He recommended that, until such a determination were made, no more brook trout should be brought in from the outside. He also recommended that, on some streams, attempts should be made to remove the exotic rainbow. He made a prophetic statement..."Fifty years hence there will be few brook trout streams and such as exist will have rainbow where the natives once were." The survey of Kelly et al. (1980) seems to have upheld this prediction. They estimated that by 1977 the original range of the native brook trout had been reduced by about 70 percent and predicted that, if current trends continue, the recovery of the brook trout may be difficult, if not impossible, and brown trout may occupy much of the territory now held by rainbow trout.

Even though the concern for the brook trout is expressed in the early literature, the 1970s survey (Kelly et al. 1980) focused attention on the problem. As a result, a number of studies have been done on this species since that time. Uplands Field Research Laboratory, Tennessee Technological University, Virginia Polytechnic Institute and State University, Cornell University, and the University of Tennessee have studied several aspects of the biology of brook trout. The Tennessee Technological University group addressed the question of whether the native brook trout is genetically different from northern populations (Harris et al. 1978). They looked at loci frequencies for several enzymes, using electrophoresis, and made comparisons of meristic characters for different populations. They concluded that the genetic and meristic differences were not great enough to warrant subspecific status. Stoneking et al. (1981), also using electrophoresis, concluded that there is enough genetic variation for subspecific status but emphasized that their fish came from only one stream, and other park populations might be different. So the question raised by Sullivan almost 50 years ago as to whether the park brook trout are different remains unresolved. The Tennessee Technology University group also studied elements of the life history of the brook trout (Konopacky 1978, Morgan and Robinette 1978, Robinette 1978) and their response to the removal of rainbow trout (Moore et al. 1981, 1983).

Studies at Uplands Laboratory have included a continuation of the removal study to determine its effectiveness over a longer period of time, structural

changes of brook trout populations as rainbow invaded them (Larson and Moore 1985), movement of brook trout (Moore, Larson, and Ridley 1985), use of angling and electrofishing to remove rainbow (Larson, Moore, Lee, in press), increase in brook trout, a comparison of the effects of stream improvement devices in virgin and formally logged watersheds, heavy metal concentrations in trout, and population control of rainbow trout (Moore, Larson, and Ridley, in press). In 1983, Norbert McKinney and Mark Alston of Uplands Laboratory did a study to assess the brook trout habitat in the park. This study is still in the manuscript stage.

In the fall of 1978, the U.S. Fish and Wildlife Service and the National Park Service attempted to reclaim parts of Sams Creek and Road Prong for brook trout by removing rainbow trout using electrofishing equipment. The streams were also sampled in the spring of 1979. This was part of a brook trout restoration program developed by Kelly (1978). This work on the restoration program was not continued. In summary, since the 1970s survey (Kelly et al. 1980), a number of studies have been conducted on the brook trout, with emphasis placed on its status in the park and its interaction with rainbow.

CREEL CENSUSES

There is very little published information on the number of trout caught by fishermen. King and Currier (1950) conducted a creel census on Little River, and Lennon (1954) did one on the Little Pigeon River. Larson and Moore of Uplands Laboratory conducted a 9-week creel census (Larson, Moore, Lee, in press). Park rangers periodically take creel information, but little use has been made of it because of its sporadic nature and lack of a statistically valid sampling scheme.

NATIVE FISHES

The survey of the fisheries information indicates that work on the sport fisheries in the park has been extensive and almost continuous since just after the park was established. Except for the work on brook trout, there has been very little done on the other fishes native to the park. Hubbs collected in the park in the summers of 1937 and 1940. He provided a list of the fishes, but unfortunately it was never published (Hubbs 1937, 1940). This list, plus others by Burrows (1935), King (1937, 1972), Holloway (1945), and Whitney (1958), contributed to a checklist of the species of the park compiled by Lennon (1961) and published in 1962. This list included 72

species, which is the number recognized as comprising the park fish fauna. Ross (1961) did a 2-year sampling study of the park fishes. Ross (1962) added two species and two subspecies to the fauna list. The efforts of these taxonomists have led to a list of park species and locations where they were collected. The only work on native fishes, other than brook trout, that has gone beyond a simple listing of species is a study by Lennon and Parker (1960) on the life history of the stoneroller, Campostoma anomalum, and a study by Stiles (1972) on three species of darters.

RECOMMENDATIONS

Sport Fisheries

This survey of the fisheries information indicates that, for the most part, it has been qualitative. With the exception of the brook trout, stoneroller, and darters, work on other native fishes is lacking. The sport fisheries information is an excellent data base for qualitative purposes and, with the exception of the Boaze and Smith data, is lacking in the ability to determine long-term trends in the fisheries resources, such as changes in standing crop. This suggests that a standardized long-term monitoring program of the sport fisheries is needed.

The data available allows one to make comparisons of the species present in a given stream at a given point in time but does not allow the determination of changes in the number of fish. It is important to initiate a long-term monitoring program that

1. samples the streams receiving the heaviest fishing pressure,
2. samples the same sections of the streams,
3. has a population estimation procedure,
4. determines the age structure of the populations, and
5. incorporates a creel census to determine the fisherman use of the resources.

Such a monitoring program is described in Part II of this report.

The surveys of King (1977), Lennon (1967), and Kelly et al. (1980) are the most extensive fisheries data sets available for the park. Neither of these investigators used a population estimation procedure, so the data give only relative abundance of the trout present. Since trout, especially brook trout, were the main concern of the surveys, the attempts to determine the numbers of

nontrout species were not great. The data, however, do provide extensive information on the species present and their relative abundance. It should be possible to determine any changes in species composition by comparing these data sets and those of Boaze and Smith, who used a population estimation procedure. One of the problems that would be encountered is the fact that, on a given stream, the surveys sampled different stream reaches. It is suggested that attempts be made to develop a data management system in which all the data for a particular stream is entered and then updated as additional data are obtained. Not only would fisheries information be entered but any additional information such as water quality. The Tennessee Aquatic Database System might allow for this type of data management.

Even though Kelly et al. (1980) were concerned mainly with brook trout distribution, their data include a list of species collected and an attempt to quantify the number of trout present. They estimated the "escapement" or the proportion of trout that escaped the electrofishing. Even though the "escapement" is subjective, it does allow comparisons of the relative abundance of fish present. The data management system suggested above would allow such comparisons.

Another problem with the fisheries information is that it is not well organized and is difficult to access. All of the available data should be computerized so that it can be used more easily. It is also important that the information be placed in a central facility, such as the GRSM library or Uplands Field Research Laboratory, soon after it is collected, whether its source is the U.S. Fish and Wildlife Service, Resources Management Division, the Uplands Laboratory, Tennessee Wildlife Resources Agency, North Carolina Wildlife Resources Commission, Tennessee Valley Authority, Oak Ridge National Laboratory, or independent investigators. The data could be obtained as part of the collecting permit process. Each individual collecting in the park would have to send copies of his data on a quarterly basis.

Centralization of the fisheries data would also help to control a problem that is probably inevitable in the scientific process; that is, an investigator taking data with him after his studies in the park have been completed or his moving to a new position. Obviously, an investigator knows his data better than anyone else, and he should use it to the fullest extent. However, when he leaves the park, copies of the data should be left for future workers. To accommodate many kinds of information from many

investigators, the data management system must be broad and inclusive. Possible systems are Database II, using the park's own computers, or more comprehensive systems such as the Tennessee Aquatic Database System. Since the latter system is designed for aquatic data, is the first of its type to be developed, and since a portion of GRSM is in Tennessee, it is recommended that the park consider using this system for data storage and retrieval. In addition, a data management system designed specifically for the park and using park computers should be considered.

Native Fishes

All of the literature about the purpose of the park emphasizes the protection and perpetuation of the native fish fauna, with sport fishing being secondary. All native plants and animals in national parks are afforded full protection by law except for fishes. Therefore, fishing in a national park is a privilege and not the primary purpose. Too much emphasis has been put on the sport fisheries in the park and not enough on the study of native species. Studies should be encouraged on nongame fishes. Lennon saw this need before leaving the park and suggested that a thorough study be made of the identification and distribution of the native fish fauna. This led to the study by Bob Ross from Virginia Polytechnic Institute and State University in 1960 and 1961; however, his work did not culminate in a parkwide species and distribution list. Unfortunately, because of this lack of knowledge, it is possible that a species may have been extirpated in the park. The smoky madtom (*Noturus baileyi*) was collected in Abrams Creek but has not been reported since Abrams Creek was poisoned with rotenone during a "reclamation" effort in 1958. It has been reported in nearby Citico Creek outside the park (Bauer et al. 1983). Another possibility is the spotfin chub (*Hybopsis monarcha*), which was reported from the park but has not been collected in recent years. Boaze (1982) compiled a list of the fishes from the lower elevation streams in which he had collected in the park. His list includes less than 50 species, considerably fewer than the 72 of Lennon's parkwide list (1962). Lennon's list includes several species that have not been collected recently.

Since GRSM is a Biosphere Reserve, with one of its functions being the preservation of native gene pools, it is imperative that studies be undertaken of native nongame fishes. Even though these species do not contribute to angler success, they are extremely important components of the

park stream ecosystems and need to be better understood.

The concern for the native brook trout is valid, and work on the species should be continued. Further studies are needed on other park populations to validate the conclusions of Stoneking et al. (1981) that the southern Appalachian brook trout is genetically different from northern populations. Even though stocking of New England strains has occurred, there are many streams with no record of stocking that presumably contain only the southern Appalachian strain. Additional studies are also needed on the interactions of brook and rainbow trout.

Recent studies (Moore et al. 1981, 1983) have indicated the impracticality of using electrofishing equipment to completely remove rainbow trout from park streams. These studies also suggest that brook trout populations increased when rainbow populations were reduced. In 1980, removal of rainbow on Lynn Camp Prong were attempted using angling. Larson, Moore, and Lee (in press) concluded that angling is more efficient for removing rainbow trout than electrofishing. Angling should be considered as a technique for reducing the rainbow in selected streams where rainbow reduction seems feasible. Further testing may show that this technique might be used periodically to maintain rainbow trout populations at levels that have little effect on brook trout populations.

Streams that contain native brook trout need to be protected vigorously. It is important for the park to maintain gene pools of Southern Appalachian brook trout. Streams that have never been stocked, are good brook trout habitat, and that are isolated from rainbow should be protected. Other streams with both rainbow and brook trout in which it appears that periodic reduction of rainbow would benefit the brook trout should be considered for rainbow removal. However, the rainbow trout should continue to be managed for its sporting qualities, especially on lower elevation streams, and not for removal as an exotic pest, considering that the rainbow trout was well established long before the park was formed, that it occupies over 80 percent of the park streams, that it affords most of the angler harvest, and that it is impractical to remove it.

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PART II

SPORT FISHERIES MONITORING PLAN

Mark Alston
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INTRODUCTION

Five species of game fish are found in Great Smoky Mountains National Park (GRSM). The brook trout (Salvelinus fontinalis) is the only native salmonid and is currently protected from fishing due to its diminishing range and population size. Two introduced species of salmonid, the rainbow trout (Salmo gairdneri) and the brown trout (Salmo trutta), provide the bulk of the fishery. Smallmouth bass (Micropterus dolomieui) and redeye bass (Ambloplites rupestris) provide good sport fishing in some of the lower elevation streams.

To properly assess the effects of fishing on these game fish populations and on sympatric nongame fish populations, a systematic monitoring of fishing pressure and fish population size is necessary. Within GRSM, this task is the responsibility of the Resources Management Division. This report outlines a procedure for long-term monitoring of sport fisheries developed by Uplands Field Research Laboratory.

Two types of data are necessary in a comprehensive monitoring program. First, there must be an assessment of the available resource. Second, there must be some measure of how the resource is being utilized. In addition, these data must be consistently obtained in a form that is easily accessible and lends itself to statistical analysis. We recommend the following monitoring plan, consisting of an electrofishing schedule to obtain fish population data and assess the resource, in conjunction with a creel census to determine fishing pressure and harvest. Information gained from this monitoring program will be stored and summarized on the park computer system.

PROCEDURES

Stream Selection

There are 333 streams in GRSM, which have a total of 734 fishable miles (1220 km) (Lennon and Parker 1960). It would be impractical to sample all of these streams on a regular basis. Since the primary purpose of this monitoring program is to detect changes in fish populations attributable to fishing pressure, the best approach is to concentrate on the heavily fished streams. It is estimated that the majority of the fishing pressure in the park is concentrated on a few lower elevation streams with relatively easy access. Since fishing pressure on other streams is not as great, impacts on those fish populations should be less. Concentrating the monitoring on heavily fished streams will allow us to develop management actions that will protect the total park fishery without sampling all streams in the park.

Since no recent creel data are available, streams to be included in the monitoring program were selected on the basis of interviews with people familiar with fishing patterns in GRSM. Major portions of six heavily fished streams have been chosen for long-term monitoring (Appendix I). The majority of these streams are low elevation, easy access streams. The stream reaches chosen are:

Abrams Creek - Mill Creek confluence (Cades Cove) downstream to the ford below the Ranger Station

Deep Creek - Headwaters downstream to Deep Creek Ranger Station

Hazel Creek - Headwaters downstream to Proctor cemetery

Little River - Gate above Elkmont downstream to park boundary at Townsend

Middle Prong, Pigeon River - Headwaters downstream to park boundary at Greenbrier

Oconaluftee River - Kephart Prong/Beech Flats confluence downstream to Raven Fork confluence

Two of the six streams are to be sampled each year, resulting in a 3-year rotation for each stream. Abrams Creek and Oconaluftee River will be sampled the first year. Middle Prong, Little Pigeon River and Little River will be sampled the second year. Hazel Creek and Deep Creek will be sampled the third year. This provides time for a comprehensive creel to be conducted on each stream while allowing samples to be taken frequently enough to detect major shifts in population characteristics or fishing pressure. Both a creel census and a population survey will be conducted on each stream.

Creel Census

For most streams, a complete census of fishermen is impossible to make. An estimate of the total number of fishermen and their catch can be made by using unbiased samples and a ratio method of estimation (Robson 1960, 1961). Such a method is valid only when sampling is done according to some statistical scheme (Malvestuto et al. 1978). At the same time, the sampling regime must allow for practical operation in the field. The best way to produce unbiased samples is to use a random sample design. Such a design selects, by chance, a value for any parameter that might influence the sample. These parameters include time of day, day of week, and direction of travel. This procedure reduces the effect of the observer's personal preferences on the sample.

In some situations, a gain in precision can be achieved by using stratified

random sampling. In this sampling procedure, the sample population is divided into nonoverlapping subpopulations or strata. Each stratum is then sampled independently. This allows a heterogeneous population to be divided into homogeneous subpopulations with a resultant reduction in between-sample variation (Cochran 1977) and a more precise estimate for the entire sample population. Stratification also allows for the possibility of sampling highly variable strata more frequently than others to reduce between-sample variation and provide for a more efficient use of limited sample time (Malvestuto et al. 1979).

To ensure unbiased samples, creel samples are scheduled by a computer program developed by Uplands Field Research Laboratory. This program produces a sample schedule utilizing stratified random samples. The program schedules the minimum number of samples needed to calculate a monthly estimate of fishing pressure and catch. Additional samples may be scheduled by the method outlined in Appendix II. These additional samples may be randomly assigned to each strata or they may be weighted so that highly variable strata are sampled more frequently. The computer program, a sample of the output, and justification for sampling criteria appear in Appendix II.

Some types of information can only be determined by interviewing fishermen. The type and number of fish caught, the time spent fishing, the number of fish creeled, the type of lure used, and several socio-economic variables are all obtained through use of interviews. A sample interview sheet is provided in Appendix III.

Manpower is one of two major factors limiting this creel program. To allow time for the other duties of the single fisheries management position in the park, the Resources Management Division of GRSM requested that the creel schedule call for a typical manpower requirement of 2 days per week. To increase sample size under this condition, each study stream is scheduled to be sampled a minimum of one 4-hour period on each of 4 days per month year-round. A 4-hour sample provides the opportunity for the creel clerk to take an additional sample during the day. Additional samples should be taken during the heavy use months of April through October, according to the method outlined in Appendix II. Seasonal or volunteer labor could be used to obtain these samples with a minimum amount of training. Further discussion of sample size is included in a later section.

Accessibility is another major factor limiting creel censusing in GRSM. This problem can be somewhat circumvented by using different methods for different levels of stream accessibility. Streams with multiple access points are best

sampled by a roving creel, in which the creel clerk moves along the stream in a systematic way, counting and interviewing fishermen. Streams with one or two access points are best sampled by an access point census, in which the clerk remains at an access point and interviews all fishermen leaving during the sample period. Both methods result in a comparable measure of fishing pressure and harvest for a specified time and stream section. All creel data should be entered into a computerized data file such as dBase II. A computer program for calculating angler success, fishing pressure, and total catch is included in Appendix III.

Roving Creel

A roving creel estimates fishing pressure by using an "instantaneous count." This consists of counting all fishermen actively fishing within the sample area in as short a time as possible. Neuhold and Lu (1957) demonstrated that a roving creel census which did not exceed one hour resulted in estimates of the number of fishermen that did not differ from direct counts made from a fixed vantage point. Thus fishing pressure will be estimated in this creel by one-hour counts of fishermen. Speed should be adjusted so that the stream is covered in approximately one hour. Active fishermen will be counted as the creel clerk passes. This method will be used on Little River, Oconaluftee River, and the Middle Prong of Little Pigeon from Ramsay Cascade parking lot downstream.

Since Little River cannot be traveled in one hour, it will be counted in two sections, with the bridge at Metcalf Bottoms as the dividing point. Each section will be counted once per sample period as specified by the computerized schedule. The other streams will be censused as one section and counted twice each sample period. Counts will be taken during the first and last hour of each 4-hour sampling period. The section to be counted first is specified by the computer schedule. The direction of the second count should be in the opposite direction from the first. The other 2 hours will be spent interviewing fishermen. Interviews may also be conducted during the counting period if time permits.

Access Point Creel

On streams where most of the fishermen enter or exit through one or two access points, a direct measure of fishing pressure and total catch can be obtained by an access point census. In this method, the creel clerk is stationed at the access point and counts all fishermen leaving. Leaving and returning by the same fisherman is counted as two separate trips. As many fishermen as

possible are interviewed to determine catch rate. This method will be used on Deep Creek, Hazel Creek, Middle Prong of the Pigeon River upstream from Ramsay Cascade parking lot, and Abrams Creek.

The access creel portion of the Pigeon River should be sampled at the same time as the roving creel portion. A single creel clerk could do an access creel for the 2 hours between the instantaneous counts of the roving creel, or two creel clerks can be used. Estimates for the two stream sections would be calculated separately and added together to obtain a total estimate for the stream. Abrams Creek has two major access points. Since each access point should be sampled proportional to its estimated use, 75 percent of the samples will be taken at the Abrams Falls parking lot in Cades Cove and 25 percent, at the gate above Abrams Creek campground. The computer schedule will indicate which station is to be sampled.

Sample Size

The manpower limitations imposed by resource management result in a scheduled sample size of one sample per stream per week. Each month this provides one sample per stratum for an access type creel or 2 samples per station for a roving type creel. If only these samples are used, confidence intervals cannot be calculated for the access creel. A missed sample prevents estimates of fishing pressure and catch from being calculated. A minimum of 2 samples per stratum per month (a total of 8 samples per stream for an access type creel) is needed to calculate confidence intervals for the estimates.

Confidence intervals indicate a range of values around the estimate that include the true value 95 percent of the time. Thus confidence intervals are a measure of the accuracy and repeatability of the estimates. Without confidence intervals or the replicate samples from which confidence intervals are derived, statistically valid comparisons between estimates cannot be made and the entire monitoring program loses much of its value.

Small sample size has several other disadvantages. It increases the chance of an erroneous estimate by increasing the impact that a single extreme sample has on the total estimate. In addition, small sample sizes generally lead to broad confidence intervals. Broad confidence intervals hamper comparisons between estimates and may mask substantial differences because of the high uncertainty surrounding the estimate. Finally, small sample sizes do not allow for more frequent sampling of highly variable strata which would provide for a more efficient use of sampling time.

The problem of limited sampling time and subsequent small sample size has been partially addressed in this monitoring plan in the following manner. First, sample periods of 4 hours are used to allow 2 samples to be taken each sampling day. Second, a method has been provided in Appendix II for scheduling additional sample periods. Finally, suggestions for evaluating the sampling scheme and determining appropriate sample sizes are included in the Recommendations section that follows.

Stream Monitoring

Periodic estimates of fish population parameters are needed to indicate the effects of fishing on the population. A number of other factors, such as water chemistry and benthic macroinvertebrate populations, also influence fish populations. Ideally, these factors should be measured and their effects studied to avoid their confounding the analysis of fishing effects on the population. This monitoring plan does not include water chemistry and benthic invertebrate measurements for three reasons. First, these parameters are extremely variable and require large sample sizes distributed throughout the year before valid comparisons can be made. This type of sampling is outside the scope of this program. Second, water chemistry and aquatic invertebrates within the park are protected from most anthropogenetic disturbance. Natural disturbances tend to be more localized and would affect only small segments of the fish population. Third, the effects of fishing on fish population dynamics are probably much greater than any other factor present in the park.

Population estimates will be made for three or four 200-meter sections of each study stream. Where possible, these sections will correspond to former U.S. Fish and Wildlife Service stations to allow comparisons with historical data. Stations will be marked with permanent tags to ensure that the same section is sampled each time. Stations have already been marked and sampled on Abrams Creek and Oconaluftee River (Appendix I). Samples should be taken in September or October of each year because (1) it is a period of relatively low water, and (2) the young of the year are larger and therefore easier to collect. These factors allow more efficient collection of fish and will contribute to a more accurate population estimate. Sampling during storm water runoff should be avoided because the increased water levels and turbidity decrease collection efficiency and estimate accuracy.

Population estimates for all fish species present will be made using the depletion method of Carle and Strub (1978). Computer programs for storing data

and calculating estimates have been adapted for use on the IBM-PC computer (Appendix IV). Fish will be removed from each section by use of backpack electroshockers. Three successive electroshocking samples will be made through each section to obtain a depletion estimate. Due to the size of the streams, three to five electroshockers in parallel should be used across the stream. The number of shockers used should be consistent from year to year and noted on data sheets. If the section has been previously sampled by the U.S. Fish and Wildlife Service, the current samples should use the same number of shockers. Fish will be anesthesized with Tricane Methysulfonate or equivalent during handling. If sufficient experienced personnel are available to quickly process fish, the use of anesthesia may be waived. Inexperienced personnel and long handling time may cause high fish mortality if anesthesia is not used. Weight and total length of each game fish will be taken. Species, number, maximum and minimum lengths, and total weight will be recorded for nongame fish. Scales will be taken from trout on the left side of the fish above the lateral line and anterior to the origin of the dorsal fin. Scales will be taken from bass and redeye on the left side of the fish in the region of the tip of the pectoral fin. The scales will be used to determine age structure and growth of game fish populations. After processing, all fish will be released within the section.

A number of factors can affect the effectiveness of fish collection by electroshocking. These factors should be measured each time a stream is sampled so that population estimates influenced by sampling conditions can be detected and taken into account. Conductivity of the water influences electroshocking effectiveness by limiting the size and strength of the electric field produced. Temperature, discharge, and turbidity influence fish distribution in the stream and the collector's ability to see them. High discharge and turbidity levels, such as those that exist after storms, are likely to produce underestimates of population size. Standard methods for measuring these parameters should be used (Appendix V). Data will be stored on a computer program presented in Appendix IV.

Cost

Most of the manpower and equipment needed to conduct this monitoring program are already present in the park. The creel schedule requires two days each week for a creel clerk. Additional manpower will be needed (7-8 people for 7-10 days per year) to accomplish electrofishing. Volunteers and other park employees may may be used to reduce costs. Three hundred dollars per year should be adequate to purchase expendables such as anesthetics, fuel for the electroshockers, and

repair/replacement of existing equipment. In addition, transportation within the park will need to be provided for the creel clerk year-round, and seasonally for the electrofishing crew.

Future Considerations/Options

1. Two additional streams, possibly Big Creek and Cataloochee Creek, could be added to the survey rotation so that each stream is sampled once every 4 years. Addition of an access creel on Little River above Elkmont might also be considered.

Responsibility: Resources Management

2. Increase sample size, especially during the heavy use months of April to October or May to September. Sample size is quite low, and validity would be improved greatly by increasing it during high use periods.

Responsibility: Science and Resources Management

3. Evaluate the program after one year of data collection for each stream. The following needs to be considered:

   a. Is the standard error of each estimate $\leq$ 10 percent of its mean? If not, then sample size must be increased.
   b. If highly variable strata are sampled more frequently, does the data substantiate the assumptions made in assigning the sampling frequency of different strata? The sampling proportions may need to be adjusted to better reflect the importance of that strata to the overall sample.

Reevaluation of the program should continue on a periodic 3 to 5 year basis thereafter.

Responsibility: Science and Resources Management

4. Investigate alternate methods for obtaining fish population estimates that would require less manpower and/or be more effective, such as mark recapture or some type of visual survey.

Responsibility: Science and Resources Management

5. Enter historical creel and population data into the park data base file as time permits.

Responsibility: Science and Resources Management

6. Conduct short-term (1-3 months) creel surveys on streams not included in the monitoring plan, especially some of the smaller, less heavily fished park streams, to see how their fishing pressure and patterns compare with those observed on streams included in the long-term monitoring plan.
Responsibility: Science and Resources Management.

7. It has been shown that weather conditions can greatly affect the accuracy of a creel census (Malvestuto et al. 1979). It may be advantageous to reschedule sample days that occur during extremely bad weather or to weight them less than other samples. Care should be taken so that this does not introduce a sample bias. Greater overall sample sizes would minimize this problem.
Responsibility: Science and Resources Management

8. Establish a separate monitoring program of overall stream health that would include water quality and macroinvertebrate surveys.
Responsibility: Science

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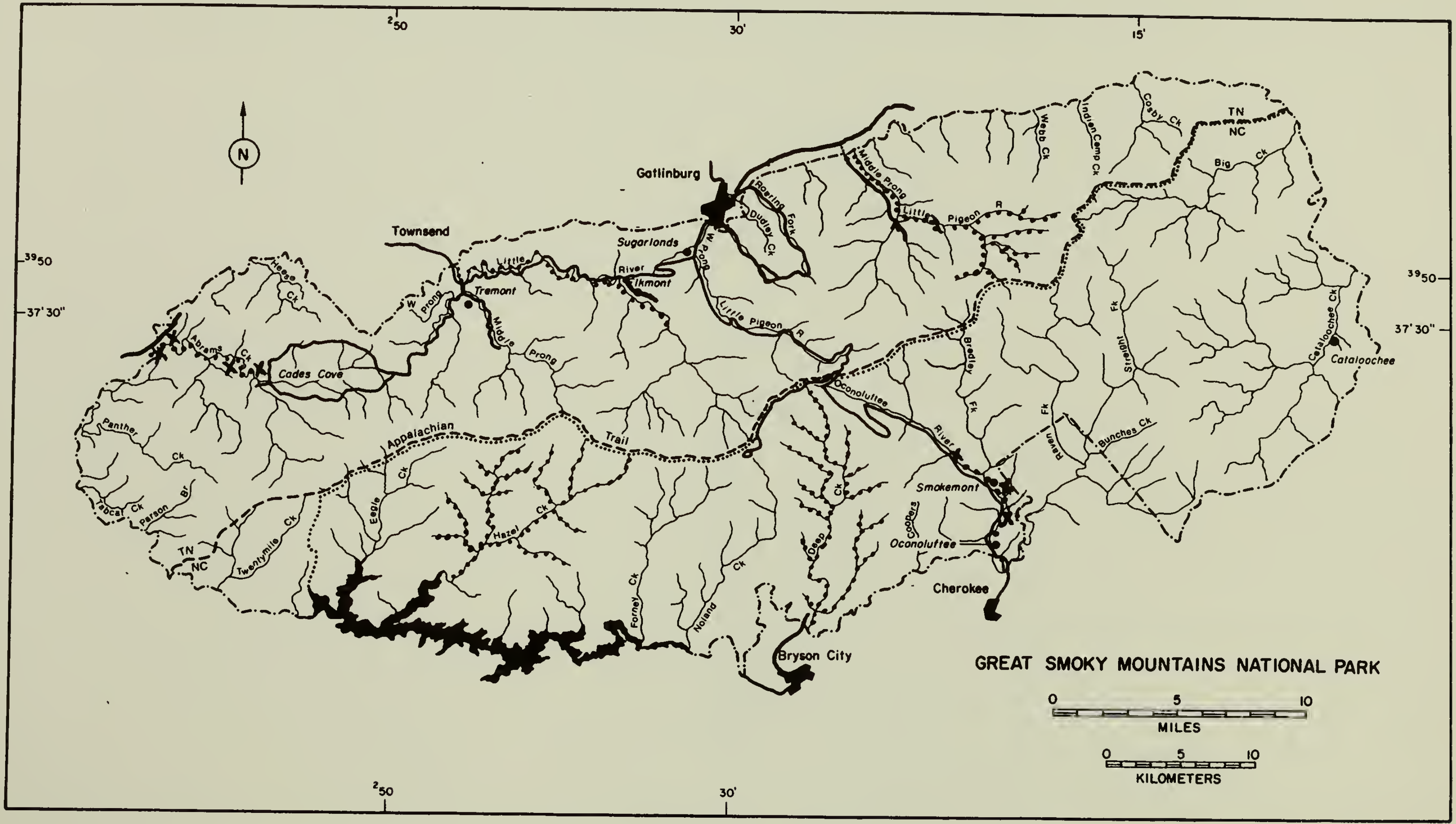
APPENDIX I

A. Map of streams to be creeled

B. List of electroshocking stations



KEY

X Electroshocking station

.... Sample stream section

APPENDIX I

B. Electroshocking stations - each section is 200 meters long measured from the location given below

		Tag Number
Abrams Creek		
	(1) Rabbit Creek Ford below Abrams Creek Campground - downstream	FS36
	(2) Buck Shank Branch - upstream	FS42
	(3) Downstream of the Horseshoe where stream turns to trail upstream	FS48 *
	(4) Mill Creek downstream	FS226 *
Oconaluftee River		
	(1) Couches Creek downstream	FS50
	(2) Smokemont sewer plant downstream	FS49 *
	(3) Collins Creek downstream	FS46 *
Little River		
	(1) 1.6 miles above White Oak Flats	P512/P513 *
	(2) 0.6 miles above Metcalf Bottoms parking lot entrance	P508/P509 *
	(3) Elkmont litter station	P506/P507 *
	(4) .3 mile below Huskey Branch	P504/P505 *
Middle Prong, Little Pigeon River		
	(1) Above confluence with Ramsay Branch	*
	(2) 0.25 miles below Ranger Station	*
	(3) Above bridge at park boundary	*

B. Electroshocking stations (cont.)

Deep Creek				
	(1)	Jenkins Place upstream		
	(2)	Below Indian Creek		
	(3)	Above the turnaround (gate) at campground		*
Hazel Creek	(1)	Confluence of Bone Valley Creek downstream	252/253	*
	(2)	Opposite Proctor House		*
	(3)	2000 feet downstream of Rowan Branch	254/255	*

* Indicates former U.S. Fish and Wildlife station

APPENDIX II

A. Instructions for computer schedule program

B. Computer schedule program

C. Sample output of B

D. Condition and justification for selection of scheduling variables

E. Scheduling additional samples

APPENDIX II.

A. Instructions for computer schedule program

CREEL.BAS

This BASIC program generates a random creel sampling regime. For a list of assumptions and justification please refer to UFRL report entitled HISTORICAL TRENDS IN FISHERIES STUDIES AND A SPORT FISHERIES MONITORING PLAN FOR GREAT SMOKY MOUNTAINS NATIONAL PARK.

This program was designed to run on an IBM-PC. Because the program is recorded at 9 sectors per track you must use PC-DOS 2.0 or greater. While the program was written for the IBM-PC the basic code should be relatively compatible with other systems that run BASIC.

To run this program you should place a disk containing BASIC.COM in the A: drive and the disk containing CREEL.BAS in the B: drive. Respond to the A> prompt by typing **BASIC B:CREEL** and then press the [**RETURN**] key. You will first be prompted to align paper in the printer and to turn it on. The program will then ask you to enter a random number. Enter a number and then press the [**RETURN**] key. The program will then print out the sampling regime. When the sampling regime has been printed the program will terminate and return the computer to the A> prompt.

B. Computer schedule program

```
100 '''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
110 ' CREEL.BAS                                                                '
120 '                                                                          '
130 ' Written by Mark MacKenzie, UFRL  06/04/84
140 '                                                                          '
150 ' This BASIC program generates a random creel sampling regime.            '
160 ' For a list of assumptions and justification please see UFRL Report      '
170 ' entitled HISTORICAL TRENDS IN FISHERIES STUDIES AND A SPORT FISHERIES   '
180 ' MONITORING PLAN FOR GREAT SMOKY MOUNTAINS NATIONAL PARK.                '
190 '                                                                          '
200 ' This program was written for the IBM-PC.                                 '
210 '                                                                          '
220 ' Three sets of DATA cards are included in the program:                   '
230 '                                                                          '
240 '          1) Stream names                                                 '
250 '          2) Average "monthly" sunrise values                             '
260 '          3) Average "monthly" sunset values                              '
270 '                                                                          '
280 '''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
290 '
300 CLS: KEY OFF
310 DIM SUNRISE(13),SUNSET(13),DAYTIM(2,4)
320 GOSUB 1670                            'Printer subroutine
330 LOCATE 6,25: RANDOMIZE                'Initialize random number generator
340 GOSUB 920                             'Initialize variables
350 GOSUB 710                             'Select streams to be sampled
360 FOR A=1 TO 13                         'Read sunrise data
370 READ SUNRISE(A)
380 NEXT A
390 FOR A=1 TO 13                         'Read sunset data
400 READ SUNSET(A)
410 NEXT A
420 LPRINT "WEEK","DAY","STREAM","DIR. SEC.","TIME"
430 LPRINT
440 FOR A=1 TO 13
450 FOR B=1 TO 4                                      '4 weeks per month
460 FOR C=1 TO 2: SECTION$(C)="": NEXT C              'Initialize section name
470 GOSUB 1130                                         'Select sample day
480 FOR C=1 TO 2
490 IF STREAM$(C)="Little River" THEN GOSUB 1470      'Select section
500 IF STREAM$(C)="Abrams Creek" THEN GOSUB 1560      'Select section
510 NEXT C
520 IF DD(1)>DD(2) GOTO 600
530 FOR C=1 TO 2
540 'The next 3 lines determine sampling direction if roving type creel
550 IF (STREAM$(C)="Oconoluftee") OR (STREAM$(C)="Pigeon River") OR (STREAM$(C)
="Little River") THEN DIR=INT(RND*(2)): ELSE DIR$=" ": GOTO 570
560 IF DIR=0 THEN DIR$="Up": ELSE DIR$="Dn"
570 LPRINT 4*(A-1)+B,DAY$(C),STREAM$(C),DIR$;"   ";SECTION$(C),TIM$(C)
580 NEXT C
590 GOTO 660
600 FOR C=2 TO 1 STEP -1
610 'The next 3 lines determine sampling direction if roving type creel
620 IF (STREAM$(C)="Oconoluftee") OR (STREAM$(C)="Pigeon River") OR (STREAM$(C)
```

```
    ="Little River") THEN DIR=INT(RND*(2)): ELSE DIR$=" ": GOTO 640
630 IF DIR=0 THEN DIR$="Up": ELSE DIR$="Dn"
640 LPRINT 4*(A-1)+B,DAY$(C),STREAM$(C),DIR$;"   ";SECTION$(C),TIM$(C)
650 NEXT C
660 NEXT B
670 GOSUB 920                                            'Reinitialize variables
680 NEXT A
690 CLS: SYSTEM
700 '
710 'Subroutine to select streams to be sampled
720 '
730 FLAG1$=" "
740 FLAG2$=" "
750 FOR I=1 TO 6
760 READ NAMES$(I)
770 NEXT I
780 CLS
790 FOR I=1 TO 6
800 LOCATE 5+I,25
810 PRINT I;" -  ";NAMES$(I)
820 NEXT
830 LOCATE 7+I,26: BEEP: INPUT "Enter number of first stream  ";S1
840 LOCATE 8+I,26: BEEP: INPUT "Enter number of second stream ";S2
850 SNAME1$=NAMES$(S1)
860 SNAME2$=NAMES$(S2)
870 IF (SNAME1$="Hazel Creek") OR (SNAME1$="Deep Creek") OR (SNAME1$=
    "Abrams Creek") THEN FLAG1$=SNAME1$
880 IF (SNAME2$="Hazel Creek") OR (SNAME2$="Deep Creek") OR (SNAME2$=
    "Abrams Creek") THEN FLAG2$=SNAME2$
890 STREAM$(1)=SNAME1$: STREAM$(2)=SNAME2$
900 RETURN
910 '
920 'Subroutine to initialize variables
930 '-Programming Note-
940 'The array DAYTIM acts as a counter to determine which day (Weekday vs
950 'Weekend) is to be sampled and at what time (Morning vs Afternoon) as
960 'follows:
970 '
980 'DAYTIM( ,0) - Weekday Morning
990 '       ( ,1) - Weekday Afternoon      Each sampled once per month
1000 '      ( ,2) - Weekend Morning        per stream.
1010 '      ( ,3) - Weekend Afternoon
1020 FOR C=1 TO 2
1030 FOR D=0 TO 3
1040 DAYTIM(C,D)=0
1050 NEXT D
1060 NEXT C
1070 LR1=0      'Little River upper section counter
1080 LR2=0      'Little River lower section counter
1090 AS1=0      'Abrams Creek upper section counter
1100 AS2=0      'Abrams Creek lower section counter
1110 RETURN
1120 '
1130 'Subroutine to select day and time of day
```

```
1140 '
1150 DD(2)=0
1160 FOR C=1 TO 2
1170 E=INT(RND*4)
1180 IF DAYTIM(C,E)=1 GOTO 1170
1190 DAYTIM(C,E)=1
1200 IF E<2 THEN DD(C)=INT(RND*5)+1 ELSE DD(C)=INT(RND*2)+6
1210 IF DD(1)=DD(2) GOTO 1200
1220 IF DD(C)=1 THEN DAY$(C)="Monday"
1230 IF DD(C)=2 THEN DAY$(C)="Tuesday"
1240 IF DD(C)=3 THEN DAY$(C)="Wednesday"
1250 IF DD(C)=4 THEN DAY$(C)="Thursday"
1260 IF DD(C)=5 THEN DAY$(C)="Friday"
1270 IF DD(C)=6 THEN DAY$(C)="Saturday"
1280 IF DD(C)=7 THEN DAY$(C)="Sunday"
1290 IF (E=0) OR (E=2) THEN T=INT(RND*((10-SUNRISE(A))*100+1))/100+SUNRISE(A)
     ELSE T=INT(RND*((SUNSET(A)-14)*100+1))/100+10
1300 HR1$=STR$(FIX(T))                                 'Starting hour
1310 IF FIX(T)<10 THEN HR1$="0"+HR1$                   'Ending hour
1320 HR2$=STR$(FIX(T+4))
1330 IF FIX(T+4)<10 THEN HR2$="0"+HR2$
1340 MIN$=STR$(FIX((T-FIX(T))*60))                     'Minutes
1350 IF FIX((T-FIX(T))*60)<10 THEN MIN$="0"+MIN$
1360 TIM$(C)=HR1$+":"+MIN$+"-"+HR2$+":"+MIN$           'Create time string
1370 WHILE INSTR(1,TIM$(C)," ")>0                      'Remove blanks from string
1380 F=INSTR(1,TIM$(C)," ")
1390 TIM$(C)=MID$(TIM$(C),1,F-1)+MID$(TIM$(C),F+1)
1400 WEND
1410 NEXT C
1420 FOR C=1 TO 2
1430 IF DD(C)=7 THEN DD(C)=0        'Make Sunday the first day of the week
1440 NEXT C
1450 RETURN
1460 '
1470 'Select section for Little River
1480 '
1490 IF LR1=2 THEN SEC(C)=2: GOTO 1520     'Max 2 upper section samples
1500 IF LR2=2 THEN SEC(C)=1: GOTO 1520     'Max 2 lower section samples
1510 SEC(C)=INT(RND*2)+1
1520 IF SEC(C)=1 THEN LR1=LR1+1: ELSE LR2=LR2+1
1530 IF SEC(C)=1 THEN SECTION$(C)="Upper": ELSE SECTION$(C)="Lower"
1540 RETURN
1550 '
1560 'Select section for Abrams
1570 '
1580 IF AS1=3 THEN SEC(C)=2: GOTO 1610     'Max 3 upper section samples
1590 IF AS2=1 THEN SEC(C)=1: GOTO 1610     'Max 1 lower section sample
1600 SEC(C)=INT(RND*2)+1
1610 IF SEC(C)=1 THEN AS1=AS1+1: ELSE AS2=AS2+1
1620 IF SEC(C)=1 THEN SECTION$(C)="Upper": ELSE SECTION$(C)="Lower"
1630 RETURN
1640 '
1650 'Printer subroutine
1660 '
```

```
1670 KEY OFF: CLS
1680 LOCATE 10,1
1690 PRINT STRING$(25,32); CHR$(201); STRING$(33,205); CHR$(187)
1700 PRINT STRING$(25,32); CHR$(186); " Align paper and turn printer on ";
1710 PRINT CHR$(186)
1720 PRINT STRING$(25,32); CHR$(186); STRING$(33,32); CHR$(186)
1730 PRINT STRING$(25,32); CHR$(186); "    Press any key to continue    ";
1740 PRINT CHR$(186)
1750 PRINT STRING$(25,32); CHR$(200); STRING$(33,205); CHR$(188)
1760 BEEP
1770 A$=INKEY$: IF A$="" THEN 1770
1780 CLS
1790 RETURN
1800 DATA "Little River","Oconoluftee","Pigeon River","Hazel Creek",
          "Deep Creek","Abrams Creek"
1810 DATA 7.7,7.42,7.2,6.57,5.68,5.38,5.4,5.68,6.37,6.4,7.12,7.23,7.62
1820 DATA 17.77,18.22,18.65,19.38,19.43,19.77,19.88,19.68,19.52,18.53,18.25,
          17.5,17.45
```

APPENDIX II.

C. Sample output of B.

WEEK	DAY	STREAM	DIR.	SEC.	TIME
1	Thursday	Little River	Dn	Upper	10:45-14:45
1	Friday	Hazel Creek			09:45-13:45
2	Friday	Little River	Up	Upper	07:43-11:43
2	Saturday	Hazel Creek			08:01-12:01
3	Sunday	Little River	Up	Lower	08:33-12:33
3	Saturday	Hazel Creek			13:33-17:33
4	Sunday	Little River	Dn	Lower	11:51-15:51
4	Thursday	Hazel Creek			12:25-16:25
5	Monday	Hazel Creek			12:58-16:58
5	Thursday	Little River	Up	Upper	13:45-17:45
6	Wednesday	Hazel Creek			08:08-12:08
6	Saturday	Little River	Dn	Upper	09:44-13:44
7	Sunday	Hazel Creek			08:03-12:03
7	Saturday	Little River	Dn	Lower	10:58-14:58
8	Tuesday	Little River	Up	Lower	07:26-11:26
8	Saturday	Hazel Creek			12:33-16:33
9	Sunday	Hazel Creek			13:08-17:08
9	Friday	Little River	Dn	Upper	08:21-12:21
10	Sunday	Little River	Dn	Upper	09:17-13:17
10	Saturday	Hazel Creek			09:47-13:47
11	Friday	Hazel Creek			09:59-13:59
11	Saturday	Little River	Dn	Lower	13:54-17:54
12	Monday	Little River	Up	Lower	10:00-14:00
12	Thursday	Hazel Creek			14:21-18:21
13	Monday	Little River	Dn	Upper	07:18-11:18
13	Saturday	Hazel Creek			12:28-16:28
14	Wednesday	Hazel Creek			13:31-17:31
14	Saturday	Little River	Dn	Upper	09:45-13:45
15	Sunday	Little River	Dn	Lower	14:24-18:24
15	Wednesday	Hazel Creek			07:27-11:27
16	Friday	Little River	Up	Lower	11:18-15:18
16	Saturday	Hazel Creek			09:32-13:32
17	Sunday	Little River	Up	Lower	15:23-19:23
17	Wednesday	Hazel Creek			07:27-11:27
18	Friday	Little River	Dn	Upper	08:54-12:54
18	Saturday	Hazel Creek			10:46-14:46
19	Tuesday	Hazel Creek			13:37-17:37
19	Friday	Little River	Dn	Upper	15:04-19:04
20	Sunday	Little River	Up	Lower	06:32-10:32
20	Saturday	Hazel Creek			06:53-10:53
21	Thursday	Little River	Dn	Lower	11:14-15:14
21	Saturday	Hazel Creek			07:15-11:15
22	Thursday	Hazel Creek			08:46-12:46
22	Saturday	Little River	Dn	Lower	12:24-16:24
23	Sunday	Little River	Up	Upper	06:21-10:21
23	Saturday	Hazel Creek			10:56-14:56
24	Thursday	Hazel Creek			10:53-14:53
24	Friday	Little River	Up	Upper	09:39-13:39
25	Monday	Little River	Up	Lower	10:58-14:58
25	Saturday	Hazel Creek			08:19-12:19
26	Sunday	Little River	Up	Upper	13:48-17:48
26	Monday	Hazel Creek			11:29-15:29

APPENDIX II.

D. Conditions and justification for selection of scheduling variables.

Creel samples are scheduled so that the impact of known sources of variability are reduced. This is accomplished by random selection of samples within subpopulations or strata that significantly differ from one another. This stratification places constraints on selection of scheduling variables. The following table outlines the scheduling variables, conditions placed on their selection, and the justification for the variable and any selection constraint.

Variable	Condition	Justification
Day	2 days per week - not a stratum but a constraint to randomly selecting days	Assures even distribution of samples across each month. Provides for more accurate estimate and helps standardize creel clerk's schedule.
Day	Stratified into weekdays and weekends	Weekend fishing pressure is probably greater and of a different nature (more locals?) than weekday pressure. Stratification assures that both types of days are sampled each month and allows differences between weekend and weekday to be recognized.
Time	Access creels only. Stratified into morning and afternoon. 4-hr samples started after 10:00 a.m. are included in the afternoon strata.	Fisherman leaving in the afternoon are more likely to have fished farther from the access point. More fishermen leave in the afternoon. Stratification allows these differences to be separated from other sources of between-sample variance.
Section	Abrams Creek only. Upper section 3 times per month. Lower section 1 time each month.	The upper section is more heavily fished.
	Little River only. Upper section 2 times per month. Lower section 2 times per month.	The length of the stream precludes sampling the entire reach in one 4-hour period. The upper and lower sections are assumed to have similar usage.
Direction	Roving creels only. Upstream 50 percent of the time. Downstream 50 percent of the time.	Reduces any sampling bias due to the direction of travel.

APPENDIX II.

E. Scheduling additional samples.

As time permits, accessory creel samples may be taken in addition to those days scheduled by the computer. These accessory samples will be important in increasing sample size and replacing scheduled creels that were unavoidably missed. However, care must be taken in scheduling extra creel samples to prevent introducing an observer bias into the estimates. Such a bias might occur if samples were preferentially taken at times or days that are utilized differently by the fishing population. To reduce the possibility of introducing such an error into the estimates, random sampling techniques should be utilized.

Samples may be totally random or may be stratified. Stratified sampling is used in the main scheduling program and has the advantage of allowing accessory samples to be preferentially selected from strata with low sample sizes or high variance. The following outlines a procedure for randomly scheduling accessory creel samples using a random numbers table. Such a table is a computer-generated series of numbers that have been selected in a random manner and listed in tabular form. Many statistics textbooks contain random number tables.

Scheduling should be completed no later than Friday of the week before the sample is to be taken. Otherwise, the timing of the scheduling itself could result in a sample bias. Similarly, once a sample has been scheduled, it should not be discarded or randomness will be lost.

First, the stratum to be sampled needs to be chosen. The roving creel has two strata: weekdays or weekend days. The access creel has four strata: morning weekdays, morning weekend days, afternoon weekdays, and afternoon weekend days. The strata to be sampled may be selected nonrandomly to increase sample size in the strata with the fewest samples or the highest variance, or it may be selected randomly. To select randomly, pick a number from the random number table by closing your eyes and arbitrarily pointing to the page. If the number is odd, then the sample should be on a weekend. An even number would indicate a weekday sample. Zero should be considered an even number. An additional number is necessary to choose the stratum on an access creel. Simply move one number to the right of the original number. If this number is even, then the sample should be a morning sample; otherwise, an afternoon sample is indicated..

After selecting the stratum, all other sample parameters, such as day of week, time of day, and direction of travel must be selected randomly. Random numbers for

for this purpose are obtained by reading successive numbers to the right of the original number chosen from the random numbers table. To determine the day of the week, refer to the next number in the line. If the stratum is a weekend, then sample Saturday if the number is odd, Sunday if the number is even. If a weekday is to be sampled, then sample Monday if the number is 0 or 1, Tuesday if 2 or 3, Wednesday if 4 or 5, Thursday if 6 or 7, and Friday if the number is 8 or 9.

To select the time of day for the roving creel, look at the next two entries in the table. If this number is greater than 24, then subtract multiples of 24 until the number is less than or equal to 24. Add this number of hours to the time of sunrise and use the result as the time to start sampling. For example, if the number is 32 and sunrise is at 0615 hours, then start at 1415 hours. If this time is outside the limits of the stratum or less than 4 hours before sunset, then use the next two numbers to select time. Several selections may be necessary for a time to be selected within the stratum. time to be selected within the stratum. Remember, morning strata must start prior to 1000 hours.

Additional sampling parameters such as direction of travel and stream section can be selected by referring to additional numbers in the table. An odd number would represent downstream; even, upstream. Similarly, an even number would represent section 1 of Little River; an odd number, section 2. Other necessary parameters can be selected in a similar manner.

APPENDIX III

A. Interview sheet and summary sheet

B. Instructions for creel analysis program

C. Computer program for creel analysis

D. Sample data and output

E. Calculation of estimates

APPENDIX III

A. Interview Sheet

Date______________ Weekday___ Weekend___ Holiday___ Location____________________________

Time Started____________ Time Creeled______________ Hours Fished____________

Range for Day____

Method of Fishing: Spinner_____ Dry Fly_____ Wet Fly_____ Other____________

Weather____

Species Creeled	Length	Weight	Scale Sample Number
Total Creeled			

Species Caught/Released	Number

Species Sought____________________

Completed Trip:____________________

Comments____________________

Other Information:

Age of Fisherman__________

Sex: M______ F______

Fisherman Zip Code________

Hometown________________

Number trip to park this year__________

Number years spent fishing park__________

Cost for Day's Trip:

Food____________________

Gas____________________

Lodging____________________

Tackle____________________

License____________________

Miles traveled today____________________

APPENDIX III

A. Interview Sheet

CREEL SUMMARY SHEET

Date ______________________________

Location ____

Time ____________________ to ____________________

If Roving: Instantaneous count #1 __________

Instantaneous count #2 __________

Access and Roving:

Interview No.	No. of fish (c)	Hours fished (h)
TOTALS		

Boxed values are required by the creel estimation program that follows.

APPENDIX III

B. Instruction for creel analysis program

SUMMARY.BAS

This BASIC program calculates total catch (H), fishing pressure (E), and success (CPE) from access and roving creels. The program also calculates confidence intervals when possible (ie. when all strata have been replicated). It is important to note that this program will function properly only when used in conjunction with the stratified random sampling design discussed in the UFRL report entitled HISTORICAL TRENDS IN FISHERIES STUDIES AND A SPORT FISHERIES MONITORING PLAN FOR GREAT SMOKY MOUNTAINS NATIONAL PARK. Please refer to documentation in the program for changes that must be made if you plan to use this program with a different sampling regime. The program uses equations developed by Malvestuto et al. 1978 in Trans. Am. Fish. Soc. 107(2).

This program was designed to run on an IBM-PC. Because the program is recorded at 9 sectors per track you must use PC-DOS 2.0 or greater. While the program was written for the IBM-PC the basic code should be relatively compatible with other systems that run BASIC.

To run this program you should place a disk containing BASIC.COM in the A: drive and the disk containing SUMMARY.BAS in the B: drive. Respond to the A> prompt by typing **BASIC B:SUMMARY** and then press the [**RETURN**] key. You will first be prompted to align paper in the printer and to turn it on. The program will then ask for information concerning the creels that you are summarizing. To enter the information type in your response and then press the [**RETURN**] key. After all the information has been entered the computer will print out the summary information. Once the summary information has been printed, the computer will ask if you wish to summarize another stream or month. Enter the appropriate response (**Y** or **N**) followed by [**RETURN**]. If you enter **Y** the program will ask you to enter a new set of data. If you enter N the program will terminate and return the computer to the A> prompt.

C. Creel analysis program

```
100 '''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
110 ' SUMMARY.BAS                                                           '
120 '                                                                       '
130 ' Written by Mark Mackenzie, UFRL, 09/20/84                             '
140 '                                                                       '
150 ' This BASIC program calculates total catch (H), fishing pressure (E),  '
160 ' and success (CPE) from access and roving creels.  The program also    '
170 ' calculates confidence intervals when possible (ie. when all strata    '
180 ' have been replicated).  It is important to note that this program     '
190 ' will function properly only when used in conjunction with the         '
200 ' stratified random sampling design discussed in the UFRL report        '
210 ' entitled HISTORICAL TRENDS IN FISHERIES STUDIES AND A SPORT FISHERIES '
220 ' MONITORING PLAN FOR GREAT SMOKY MOUNTAINS NATIONAL PARK.              '
230 '                                                                       '
240 ' The expansion factors [variables EX(i) and W(i)] and other parts of   '
250 ' this program must be changed if one wishes to use this program with a '
260 ' different sampling regime.                                            '
270 '                                                                       '
280 ' This program uses equations developed by Malvestuto et al. 1978.      '
290 ' Trans. Am. Fish. Soc. 107(2).                                         '
300 '                                                                       '
310 ' This program was written for the IBM-PC connected to an IBM/Epson     '
320 ' dot matrix printer.  The program contains some printer control        '
330 ' characters which may not be suitable for other printers.              '
340 '                                                                       '
350 ' Three sets of DATA cards are included in the program:                 '
360 '                                                                       '
370 '   1) Mean "monthly" day lengths.                                      '
380 '   2) Mean number of hours from sunrise to noon by "month."            '
390 '   3) Two-sided t values for p=.05 and degrees of freedom from         '
400 '       1 to 20.                                                        '
410 '                                                                       '
420 '''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
430 '
440 DIM EST(20,3),TIME(20),SUM(4,3),NUM(4),MEAN(4,3),EXPA(4,3),VARS(4,3),
   SS(4,3),TEMP(3,2),DAY$(4),DD(13),TT(20),B4(20),B5(20),HRS(13)
450 A1=0: H=0: E=0: CPE=0: FLAG1=0: FLAG2=0
460 GOSUB 2480
470 FOR I=1 TO 13
480 READ DD(I)            'Read mean "monthly" day lengths
490 NEXT I
500 FOR I=1 TO 13
510 READ HRS(I)
520 NEXT I
530 FOR I=1 TO 20
540 READ TT(I)            'Read t values
550 NEXT I
560 PRINT "Input sampling ";CHR$(34);"month";CHR$(34);" (1-13)";: INPUT DAT
570 IF (DAT<1) OR (DAT>13) GOTO 560
580 D=DD(DAT)
590 PRINT: INPUT "Input year"; YEAR
600 PRINT: INPUT "Input stream name"; NAM$
```

```
610 PRINT: INPUT "Input creel type: Access or Roving (A/R)"; TYPE$
620 IF (TYPE$<>"a") AND (TYPE$<>"A") AND (TYPE$<>"r") AND (TYPE$<>"R") GOTO 610
630 IF (TYPE$="a") OR (TYPE$="A") THEN A2=4: ELSE A2=2
640 IF A2=2 GOTO 680
650 DAY$(1)="Morning Weekday": DAY$(2)="Morning Weekend"
660 DAY$(3)="Afternoon Weekday": DAY$(4)="Afternoon Weekend"
670 GOTO 690
680 DAY$(1)="Weekday": DAY$(2)="Weekend"
690 IF (TYPE$="a") OR (TYPE$="A") THEN GOSUB 780: ELSE GOSUB 990  'Enter data
700 GOSUB 1250                                  'Calculate estimates
710 IF FLAG1=0 THEN GOSUB 1560                 'Calculate variance, if possible
720 GOSUB 1900                                 'Print results
730 CLS: INPUT "Do you wish to enter data for another stream or month (Y/N)";
    CC$
740 IF (CC$<>"y") AND (CC$<>"Y") AND (CC$<>"n") AND (CC$<>"N") GOTO 730
750 IF (CC$="y") OR (CC$="Y") THEN CLS: CLEAR: GOTO 440: ELSE CLS: SYSTEM
760 END
770 '
780 'Access creel subroutine
790 '
800 A1=A1+1
810 CLS: INPUT "Input total catch"; EST(A1,1)
820 PRINT: INPUT "Input total hours fished"; EST(A1,2)
830 EST(A1,3)=EST(A1,1)/EST(A1,2)
840 FOR I=1 TO 2
850 EST(A1,I)=EST(A1,I)/4                              'Set to hourly basis
860 NEXT I
870 CLS
880 FOR I=1 TO 4
890 PRINT I; "="; DAY$(I)
900 NEXT I
910 PRINT
920 INPUT "Input the appropriate sample time number"; TIME(A1)
930 IF (TIME(A1)>4) OR (TIME(A1)<1) GOTO 920
940 CLS: INPUT "Do you wish to enter another survey for this stream (Y/N)"; A3$
950 IF (A3$<>"Y") AND (A3$<>"y") AND (A3$<>"N") AND (A3$<>"n") GOTO 940
960 IF (A3$="Y") OR (A3$="y") GOTO 780
970 RETURN
980  '
990  'Roving creel subroutine
1000 '
1010 A1=A1+1
1020 CLS: INPUT "Input number of instantaneous counts"; B1
1030 B3=0
1040 FOR I=1 TO B1
1050 PRINT: PRINT "Input number in instantaneous count";I;: INPUT B2
1060 B3=B3+B2
1070 NEXT I
1080 EST(A1,2)=B3/B1*D                         'Mean of instantaneous counts
1090 CLS: INPUT "Input total catch"; B4(A1)
1100 PRINT: INPUT "Input total hours fished"; B5(A1)
1110 EST(A1,3)=B4(A1)/B5(A1)
```

```
1120 EST(A1,1)=EST(A1,2)*EST(A1,3)
1130 CLS
1140 FOR I=1 TO 2
1150 PRINT I; "="; DAY$(I)
1160 NEXT I
1170 PRINT
1180 INPUT "Input the appropriate sample day number"; TIME(A1)
1190 IF (TIME(A1)>2) OR (TIME(A1)<1) GOTO 1180
1200 CLS: INPUT "Do you wish to enter another survey for this stream (Y/N)";
     B6$
1210 IF (B6$<>"Y") AND (B6$<>"y") AND (B6$<>"N") AND (B6$<>"n") GOTO 1200
1220 IF (B6$="Y") OR (B6$="y") GOTO 1010
1230 RETURN
1240 '
1250 'Subroutine to calculate estimate means and multiply by expansion factors
1260 '
1270 FOR I=1 TO A1
1280 FOR J=1 TO 3
1290 SUM(TIME(I),J)=SUM(TIME(I),J)+EST(I,J)   'Sum of individual estimates
1300 NEXT J
1310 NUM(TIME(I))=NUM(TIME(I))+1              'Number in each strata
1320 NEXT I
1330 'Expansion factors
1340 IF A2=2 GOTO 1380
1350 EX(1)=20*HRS(DAT): EX(2)=8*HRS(DAT): EX(3)=20*(D-HRS(DAT)):
     EX(4)=8*(D-HRS(DAT))
1360 W(1)=EX(1)/(28*D): W(2)=EX(2)/(28*D): W(3)=EX(3)/(28*D): W(4)=EX(4)/(28*D)
1370 GOTO 1400
1380 EX(1)=20: EX(2)=8
1390 W(1)=20/28: W(2)=8/28
1400 IF A2=4 THEN N=28*D: ELSE N=28
1410 FOR I=1 TO A2
1420 FOR J=1 TO 3
1430 IF NUM(I)=0 THEN FLAG1=I: GOTO 1520      'Check for missing strata
1440 MEAN(I,J)=SUM(I,J)/NUM(I)                'Strata mean
1450 EXPA(I,J)=MEAN(I,J)*EX(I)/N
1460 NEXT J
1470 H=H+EXPA(I,1)                           'Overall estimates
1480 E=E+EXPA(I,2)
1490 CPE=CPE+(EXPA(I,3))
1500 NEXT I
1510 H=H*N: E=E*N: CPE=CPE*N
1520 RETURN
1530 '
1540 'Subroutine to calculate variance and confidence interval
1550 '
1560 'Calculate estimate variance by strata
1570 FOR I=1 TO A1
1580 FOR J=1 TO 3
1590 SS(TIME(I),J)=SS(TIME(I),J)+(EST(I,J)-MEAN(TIME(I),J))^2  'Strata SS
1600 NEXT J
1610 NEXT I
```

```
1620 FOR I=1 TO A2
1630 FOR J=1 TO 3
1640 IF NUM(I)-1=0 THEN FLAG2=I: GOTO 1880
1650 VARS(I,J)=SS(I,J)/(NUM(I)-1)            'Strata variance
1660 NEXT J
1670 NEXT I
1680 'Calculate estimate variance, standard error, and confidence intervals
1690 FOR I=1 TO A2
1700 FOR J=1 TO 3
1710 TEMP(J,1)=TEMP(J,1)+W(I)^2*VARS(I,J)/NUM(I)   'Summations for use in
1720 TEMP(J,2)=TEMP(J,2)+W(I)*VARS(I,J)/N          'calculating variance
1730 NEXT J
1740 NEXT I
1750 NMIN=NUM(1)
1760 NSUM=0
1770 FOR I=1 TO A2
1780 IF NUM(I)<NMIN THEN NMIN=NUM(I)
1790 NSUM=NSUM+NUM(I)
1800 NEXT I
1810 DF=NSUM-CINT((NSUM-(NMIN-1))/2)  'Equation to determine degrees of freedom
1820 IF DF>20 THEN PRINT "Input two-tailed t value with p=.05 and";DF;
     " degrees of freedom";: INPUT T: ELSE T=TT(DF)
1830 FOR I=1 TO 3
1840 VAR(I)=TEMP(I,1)-TEMP(I,2)     'Overall variance
1850 SE(I)=SQR(VAR(I))*N            'Standard error
1860 CI(I)=T*SE(I)                  'Confidence interval
1870 NEXT I
1880 RETURN
1890 '
1900 'Print results subroutine
1910 '
1920 LPRINT: LPRINT: LPRINT: LPRINT: LPRINT
1930 LPRINT CHR$(14); "Creel Survey Summary"
1940 LPRINT: LPRINT: LPRINT NAM$
1950 LPRINT: LPRINT "Sampled ";CHR$(34);"Month";CHR$(34);DAT;CHR$(8);",";YEAR
1960 LPRINT
1970 IF A2=4 THEN LPRINT "Access Creel": ELSE LPRINT "Roving Creel"
1980 LPRINT: LPRINT: LPRINT
1990 LPRINT "Input data:": LPRINT
2000 IF A2=2 GOTO 2080
2010 'Print access creel data
2020 LPRINT: LPRINT "Strata:",," Total Catch:"," Hours Fished:": LPRINT
2030 FOR I=1 TO A1
2040 LPRINT DAY$(TIME(I)),EST(I,1)*4,EST(I,2)*4
2050 NEXT I
2060 GOTO 2130
2070 'Print roving creel data
2080 LPRINT ," _"
2090 LPRINT "Strata:"," X of Counts:"," Total Catch:"," Hours Fished:": LPRINT
2100 FOR I=1 TO A1
2110 LPRINT DAY$(TIME(I)),EST(I,2)/D,B4(I),B5(I)
2120 NEXT I
```

```
2130 LPRINT: LPRINT: LPRINT
2140 IF FLAG1>0 GOTO 2420
2150 LPRINT ,," Estimate +";CHR$(8);"_ 95% confidence interval:"
2160 LPRINT
2170 IF FLAG2>0 GOTO 2290
2180 LPRINT "Total Catch (H):",
2190 LPRINT USING "######.##_ _+";H;
2200 LPRINT CHR$(8);"_";: LPRINT USING "#####.##"; CI(1)
2210 LPRINT "Fishing Pressure (E):",
2220 LPRINT USING "######.##_ _+";E;
2230 LPRINT CHR$(8);"_";: LPRINT USING "#####.##"; CI(2)
2240 LPRINT "Success (CPE):",
2250 LPRINT USING "######.##_ _+";CPE/N;
2260 LPRINT CHR$(8);"_";: LPRINT USING "#####.##"; CI(3)/N
2270 GOTO 2450
2280 'Only print estimates due to unreplicated stratum
2290 LPRINT "Total Catch (H):",
2300 LPRINT USING "######.##";H;
2310 LPRINT ,"Confidence limits cannot be"
2320 LPRINT "Fishing Pressure (E):",
2330 LPRINT USING "######.##";E;
2340 LPRINT ,"calculated because there was"
2350 LPRINT "Success (CPE):",
2360 LPRINT USING "######.##";CPE;
2370 LPRINT ,"only one sample in the"
2380 LPRINT ,,,DAY$(FLAG2);" stratum"
2390 LPRINT ,,,"(and possibly other strata)."
2400 GOTO 2450
2410 'No estimates due to missing stratum
2420 LPRINT "Estimates of Total Catch (H), Fishing Pressure (E), and Success (CPE)
2430 LPRINT "cannot be made using this program because the "; DAY$(FLAG1);
     " stratum"
2440 LPRINT "(and possibly other strata) was not sampled."
2450 LPRINT CHR$(12)
2460 RETURN
2470 '
2480 'Printer subroutine
2490 KEY OFF: CLS
2500 '
2510 LOCATE 10,1
2520 PRINT STRING$(25,32); CHR$(201); STRING$(33,205); CHR$(187)
2530 PRINT STRING$(25,32); CHR$(186); " Align paper and turn printer on ";
2540 PRINT CHR$(186)
2550 PRINT STRING$(25,32); CHR$(186); STRING$(33,32); CHR$(186)
2560 PRINT STRING$(25,32); CHR$(186); "    Press any key to continue    ";
2570 PRINT CHR$(186)
2580 PRINT STRING$(25,32); CHR$(200); STRING$(33,205); CHR$(188)
2590 BEEP
2600 A$=INKEY$: IF A$="" THEN 2600
2610 CLS
2620 RETURN
```

```
2630 DATA 10.07,10.8,11.45,11.82,13.75,14.38,14.48,14,13.15,12.13,11.13,10.27,
     9.83
2640 DATA 4.92,5.16,5.71,6.35,6.91,7.35,7.33,6.88,6.55,6.2,5.81,5.4,4.98
2650 DATA 12.71,4.3,3.18,2.77,2.57,2.45,2.36,2.31,2.62,2.23,2.2,2.18,2.16,2.14,
     2.13,2.12,2.11,2.1,2.09,2.08
```

APPENDIX III

D. Sample data and output for C

Creel Survey Summary

ROVING CREEL TEST

Sampled "month" 1, 1984

Roving Creel

Input data:

Strata:	$\bar{X}$ of Counts:	Total Catch:	Hours Fished:
Weekday	5	20	20
Weekday	1	3	4
Weekday	10	20	70
Weekday	5	4	10
Weekday	3	15	15
Weekend	10	45	30
Weekend	2	4	6
Weekend	15	60	75
Weekend	6	4	35

	Estimate $\pm$ 95% confidence interval:
Total Catch (H):	1124.67 $\pm$ 586.99
Fishing Pressure (E):	1620.00 $\pm$ 742.85
Success (CPE):	0.71 $\pm$ 0.27

APPENDIX III

D. Sample data and output for C

Creel Survey Summary

ACCESS CREEL TEST

Sampled "Month" 1, 1984

Access Creel

Input data:

Strata:	Total Catch:	Hours Fished:
Morning Weekday	20	20
Morning Weekday	3	4
Morning Weekend	45	30
Morning Weekend	4	6
Afternoon Weekday	20	70
Afternoon Weekday	4	10
Afternoon Weekday	15	15
Afternoon Weekend	60	75
Afternoon Weekend	4	35

	Estimate $\pm$ 95% confidence interval:
Total Catch (H):	1671.00 $\pm$ 1523.54
Fishing Pressure (E):	2722.67 $\pm$ 2234.19
Success (CPE):	0.70 $\pm$ 0.31

APPENDIX III.

E. Calculation of estimates.

Sample parameters for the access point creel and the roving creel are calculated by different methods. With an access point creel, fishing pressure and catch are estimated by direct expansion. Success is the ratio of catch and pressure. In a roving creel, fishing pressure is estimated by expansion of the instantaneous count, success is determined by the interview, and total catch is calculated as the product of pressure and success.

Estimates are calculated for each sample. The mean of these estimates for each 4-week period is then expanded to give an estimate. Both the estimate and the sample schedule are based on 13 4-week periods per year. This simplifies both the scheduling and the estimation procedure. These 4-week estimates will be referred to as monthly estimates for convenience.

The sampling procedure in this creel plan consists of stratified random samples. Samples are randomly chosen within discrete levels such as time period or area. This type of stratified sampling allows more time to be spent in those areas or time periods that have the greatest activity. It also requires that estimates for each strata be calculated separately. This helps to remove any bias produced by varying sampling intensities.

Expansion is accomplished by multiplying the sample mean by an expansion factor that represents the number of possible samples within a 28-day period. A step by step description of estimate calculation follows.

(1) Calculate the sample parameters for each sample in the month. Each strata will be calculated separately. These calculations are different for roving and access creel.

Access Point

Total catch (H) $H = \Sigma_1^f c$

where c = # of fish creeled by each fisherman; f = # of fishermen.

Fishing pressure (E) $E = \Sigma_1^f h$

where h = # of hours fished by each fisherman

Success (CPE) CPE = H/E

For H and E, divide sample values by the length of the sample period (usually 4 hours) to obtain hourly values.

Roving

Total catch (H) = CPE x E

Fishing pressure (E) = $((\Sigma_1^i f)/i)d$

where f = # of fishermen counted in an instantaneous count;
i = # of instantaneous counts during the sample period.
d = average daylight hours (see table on next page)

Success $CPE = \Sigma_1^n c / \Sigma_1^n h$

where n = # of interviews
c = # of fish creeled by each fisherman
h = # of hours fished by each fisherman

(2) Calculate a mean for each variable in each strata for the month (28 days) as

$$\overline{Y}_s = {}^{s}_{1} \; Y_i / s$$

where Y_i = ith value of a sample parameter in stratum s
s = number of samples in a stratum

(3) Calculate the variance for each sample strata by

$V_s = \Sigma((Y-\overline{Y})^2/n - 1)$

where Y = sample parameter such as E, etc.
n = total # of samples

(4) Calculate the mean value for the month $\overline{Y}_m$ as

$$\Sigma_1^L \; N_h \; (\overline{Y}_s) \; /N$$

where L = # of strata
$\overline{Y}_s$ = mean value for stratum s
N_s = total units in s stratum
N = total units in month

If Roving

N = 28 days
L = 2

Weekdays $N_s = 8$
Weekends $N_s = 20$

If Access

N = 28d hours
L = 4

	Morning	Afternoon
Weekdays	20m	20 (d-m)
Weekends	8m	8 (d-m)

Month	Week	Ends	Average Daylight Hours (d)	Average Morning Hours (m)
1	1-4	Jan 28	10.07	4.92
2	5-8	Feb 25	10.80	5.16
3	9-12	Mar 24	11.45	5.71
4	13-16	Apr 21	11.82	6.35
5	17-20	May 19	13.75	6.91
6	21-24	Jun 16	14.38	7.35
7	25-28	Jul 14	14.48	7.33
8	29-32	Aug 11	14.00	6.88
9	33-36	Sep 8	13.15	6.55
10	37-40	Oct 6	12.13	6.20
11	41-44	Nov 3	11.13	5.81
12	45-48	Dec 1	10.27	5.40
13	49-52	Dec 31	9.83	4.98

where week 1 starts January 1.

(5) Calculate the variance of the mean monthly value V_m as

$$\Sigma_1^L W^2 V_s/N_s - \Sigma_1^L W V_s/P$$

where $W = N_s/N$

P = # of samples

(6) Calculate the standard error by $\sqrt{V_m} = se$

For estimates of success, skip to step 9.

(7) Expand monthly mean values $\bar{Y}_m$ to give monthly estimates ($\hat{Y}$) by multiplying $\bar{Y}_m$ by the correct expansion factor.

$$\hat{Y} = \bar{Y}_m N$$

(8) Estimate the standard error of $\hat{Y}$ as $N(se) = S$

(9) Calculate confidence limits by

$$\hat{Y} = \Sigma(t_{.05\ (n-1)})S$$

where t is taken from a students-t distribution table with $\alpha = .05$ and n-1 degrees of freedom

NOTE: During an access point creel there may be times when a fisherman leaves without being interviewed. If this occurs, assign that fisherman the mean sample values of catch and hours fished and include him in the analysis.

This procedure follows that outlined in Malvestuto et al. 1978 and Cochran 1977.

APPENDIX IV

A. Instructions for population estimate program

B. Population estimate program

C. Sample data and output for A

D. Data sheets for fish population survey

APPENDIX IV.

A. Instructions for population estimate program

FISHPOP.BAS

This BASIC program estimates fish population size based on three electroshocking runs. The equations used in this program are based on those found in "Carle, S.L. and M.R. Strumb 1978. A new method for estimating population size from removal data. Biometrics 34:621-630."

This program was designed to run on an IBM-PC. Because the program is recorded at 9 sectors per track you must use PC-DOS 2.0 or greater. While the program was written for the IBM-PC the basic code should be relatively compatible with other systems that run BASIC.

To run this program you should place a disk containing BASIC.COM in the A: drive and the disk containing FISHPOP.BAS in the B: drive. Respond to the A> prompt by typing **BASIC B:FISHPOP** and then press the [**RETURN**] key. You will first be prompted to align paper in the printer and to turn it on. The program will then ask for the number of individuals collected in the first run. Enter the appropriate number and then press the [**RETURN**] key. Repeat this same procedure for the remaining two runs. The program will then output the population estimate and confidence interval (when possible). Pressing the [*] key at this time will terminate the program and return the computer to the A> prompt. Pressing any key but [*] will allow you to enter more data.

In some instances the calculation of confidence intervals will not be possible. This happens when a division by zero would occur or when the number of individuals collected in the runs is such that a violation of assumptions as stated in Carle et al. (1978) would occur. Please refer to Carle et al. (1978) for further information.

APPENDIX IV.

B. Population estimate program

```
100 ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
110 ' FISHPOP.BAS  Version 1.1                                                 '
120 '                                                                          '
130 ' Written by:  Mark MacKenzie, UFRL                                        '
140 ' Date:        October 10, 1984                                            '
150 '                                                                          '
160 ' This BASIC program estimates fish population size from data collected '
170 ' from three electro-shocking runs.  Equations used in this program are '
180 ' from Carle, S.L. AND M.R. Strum.  1978.  A new method for estimating  '
190 ' population size from removal data.  Biometrics 34:621-630.            '
200 '                                                                          '
210 ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
220 KEY OFF
230 GOSUB 880
240 TOT=0
250 FLAG=0
260 CLS
270 INPUT "Number caught in run 1:  ",C(1)
280 LPRINT "Number caught in run 1:  ",C(1)
290 INPUT "                        run 2:  ",C(2)
300 LPRINT "                        run 2:  ",C(2)
310 INPUT "                        run 3:  ",C(3)
320 LPRINT "                        run 3:  ",C(3)
330 K=3
340 GOSUB 420
350 GOSUB 620
360 GOSUB 750
370 LOCATE 23,1: PRINT "Press [*] key to exit, any other key to continue."
380 A$=INKEY$: IF A$="" GOTO 380:
390 IF A$="*" THEN CLS: SYSTEM
400 GOTO 240
410 END
420 'Subroutine to determine population estimate
430 R=K
440 T=0
450 X=0
460 FOR I=1 TO K
470 T=T+C(I)
480 X=X+C(I)*(K-I)
490 NEXT I
500 N=T-1
510 IF N-T+1=0 THEN N=N+1
520 FIRST=(N+1)/(N-T+1)
530 NUM=K*N-X-T+1+K
540 DENOM=K*N-X+2+K
550 SECOND=1
560 FOR I=1 TO K
570 SECOND=SECOND*((NUM-I)/(DENOM-I))
580 NEXT I
590 EQ=FIRST*SECOND
600 IF EQ>1 THEN N=N+1: GOTO 520
610 RETURN
```

```
620 'Subroutine to determine confidence intervals
630 IF K+N-X=0 GOTO 730
640 P=T/(K+N-X)
650 Q=1-P
660 QC=Q^K
670 IF 1-QC>0 GOTO 730
680 SE=SQR(-(N*QC*(1-QC))/((1-QC)^2-(R*P)^2*(Q^(R-1))))
690 BL=CINT(N-SE*1.96)
700 UL=CINT(N+SE*1.96)
710 IF BL<T THEN BL=T
720 GOTO 740
730 FLAG=1
740 RETURN
750 PRINT: PRINT
760 LPRINT: LPRINT
770 PRINT "Population","Confidence","Sample"
780 LPRINT "Population","Confidence","Sample"
790 PRINT "Estimate:","Interval:","Total:": PRINT
800 LPRINT "Estimate:","Interval:","Total:": LPRINT
810 IF FLAG=0 THEN PRINT N,BL;"-";UL,T
820 IF FLAG=0 THEN LPRINT N,BL;"-";UL,T
830 IF FLAG=1 THEN PRINT N,"   *   ",T: PRINT: PRINT:
    PRINT "* Confidence intervals cannot be calculated."
840 IF FLAG=1 THEN LPRINT N,"   *   ",T: LPRINT: LPRINT:
    LPRINT "* Confidence intervals cannot be calculated."
850 LPRINT: LPRINT
860 FLAG=0
870 RETURN
880 'Printer subroutine
890 KEY OFF: CLS
900 LOCATE 10,1
910 PRINT STRING$(25,32); CHR$(201); STRING$(33,205); CHR$(187)
920 PRINT STRING$(25,32); CHR$(186); " Align paper and turn printer on ";
930 PRINT CHR$(186)
940 PRINT STRING$(25,32); CHR$(186); STRING$(33,32); CHR$(186)
950 PRINT STRING$(25,32); CHR$(186); "    Press any key to continue    ";
960 PRINT CHR$(186)
970 PRINT STRING$(25,32); CHR$(200); STRING$(33,205); CHR$(188)
980 BEEP
990 A$=INKEY$: IF A$="" THEN 990
1000 CLS
1010 RETURN
```

APPENDIX IV

C. Sample data and output for B.

Number caught in	run 1:	10
	run 2:	4
	run 3:	2

Population Estimate:	Confidence Interval:	Sample Total:
16	16 - 25	16

STREAM SURVEY

Page _____ of _____

Date _______________
Location _______________

Run	Species	Total Length mm	Weight (g)	Scale Sample #	Age

STREAM SURVEY SUMMARY

DATE ____________________

LOCATION ____

NUMBER OF SHOCKERS ____________________

LENGTH OF SECTION ____________________

COLLECTORS ____

____

Fish Species*	Run 1	Run 2	Run 3	Total Fish	Total Weight	Max Length	Min Length	Population Estimate

*Individual lengths and weights of game fish should be recorded separately.

Temperature ________ °C

pH ________

	1	2	3	Mean
Stream depths (cm)				
Current (cm/sec)				
Stream width (cm)				

Conductivity ____________

O_2 ____________ PPM

Turbidity ____________ Discharge ____________

Comments:

____

____

____

APPENDIX V

Standard methods for physical/chemical stream parameter measures

Standard Methods for Physical/Chemical Stream Parameter Measures

Temperature (^{o}C), pH, dissolved oxygen (ppm), and conductivity (microhms) can all be determined by use of the appropriate analytical meter. Many meters are capable of several functions. An in-the-field measurement should be used when possible.

Turbidity can be quantitatively measured using a nepholometer. However, for this program a qualitative measure of turbidity is adequate. The following definitions should be used when "measuring" turbidity.

Clear - normal condition of water in the park - excellent visibility.

Colored - water is transparent but contains dissolved substances and some suspended particles that reflect light - usually a brown tea-like color - often occurs after a short rain. Visibility through water still good.

Turbid - water no longer clear. Visibility through water greatly reduced to a few centimeters; may be greenish or brown colored.

Muddy - no visibility through water; lots of suspended particles usually present after long hard rain.

Discharge is calculated from stream depth, stream current, and stream width. Depth and current should be measured in the middle of the stream and halfway to each bank. Current should be measured using a current meter held 2/3 of the depth from the stream bottom. Width should be measured perpendicular to the stream flow at the same location. These measurements should be made at the downstream marker of the section to ensure consistency between years. All measurements should be in centimeters and $^{cm}/sec$.

Discharge (cm^3/sec) = mean depth x mean current x width.

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environment and cultural value of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.